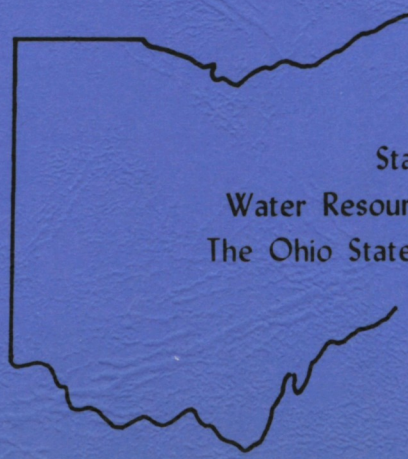
WATER
WATER
WATER
WATER
WATER
WATER
WATER
WATER
WATER
WATER

Report No. G-926-01

ANNUAL PROGRAM REPORT Fiscal Year 1984

Robert C. Stiefel

United States
Geological Survey



State of Ohio
Water Resources Center
The Ohio State University

Report No.
G-926-01

Fiscal Year 1984 Program Report
Grant No. 14-08-0001-G-926

for

U.S. Department of the Interior
Geological Survey

by

Water Resources Center
The Ohio State University
Columbus, Ohio 43210

Robert C. Stiefel, Director

September 1985

"The research on which the report is based was financed in part by the United States Department of the Interior, Geological Survey, through the Ohio Water Resources Center."

ABSTRACT

Water is one of Ohio's most important natural resources, and the State has an abundant supply to meet its immediate needs. Most of Ohio's water problems are associated with water quality. Of concern are the sediments, nutrients and acids in the surface waters from urban, agricultural and mining areas and the toxic and hazardous wastes that threaten the ground and surface waters. The focus of the 1984 State Water Research Program was directed at some of these needs. One project investigated the operational parameters of a fluidized bed bioreactor for the treatment of a wastewater to establish the optimal design and operating criteria for the unit. Three of the projects explored the significance of phosphorus to the State's surface water quality: one developed a technique to estimate the amount of dissolved phosphorus being transport by agricultural runoff; a second better defined the role that agricultural herbicides have in inhibiting photosynthesis and the removal of nutrients in streams in the Lake Erie Basin, and a third investigated the relationships that exist between bioavailable and non-bioavailable particulate phosphorus in Lake Erie. Other projects attempted to manipulate the fish population in the Lake by changing the type of habitat within the regions managed wetlands by altering the depth of water; and explored the quantities of materials involved in the transport of sediment and nutrients from the Lake Erie shoreline to the off-shore waters. The Center's technology transfer program assisted in the development of a computer program to estimate the soil loss resulting from surface runoff on agricultural lands.

TABLE OF CONTENTS

WATER PROBLEMS AND ISSUES OF OHIO

Water is one of Ohio's most important natural resources. Bounded on the north by Lake Erie and on the south by the Ohio River and containing other extensive ground and surface waters, Ohio has an adequate supply of water to meet its immediate needs. However, the combination of large, heavily industrialized urban centers; extensive agricultural activities; high volume coal production and large coal reserves; and the associated demands for new energy production continues to cause concerns related to water quality and water management. In addition, extreme hydrologic events cause localized problems of both excessive water and water deficiencies at times.

Surface Water

The northern 25 percent of Ohio's area drains into Lake Erie, while the southern portion drains into the Ohio River. Runoff from Ohio's streams and rivers averages about 25 billion gallons per day. The state also receives nearly a billion gallons of runoff daily which drains through the Maumee River to Lake Erie from the neighboring state of Indiana; and Ohio has access to additional flows past its boundaries in Lake Erie and the Ohio River that total well over 150 billion gallons of water per day.

Last year, over 16 billion gallons of water were withdrawn from Ohio's surface sources each day to meet the demands for municipal supplies; rural needs for domestic and livestock purposes; irrigation; and self-supplied industrial needs including cooling water for thermo- electric power generation. These demands account for only 60 percent of the available surface waters in the state's streams each day, and localized shortages only develop during certain dry seasons and periodic droughts.

The combined length of all the streams in Ohio approaches 44,000 miles, which means that there is approximately one mile of stream for each square mile of surface area in the state. In addition, there are more than 50,000 lakes, ponds and reservoirs within the state having a combined surface area of 200,000 acres. Only a small fraction of these, about 6,700 acres, occur naturally. The remainder are man-made impoundments that range in size from small farm ponds to large multipurpose reservoirs.

The reservoirs in the state are used to provide water for many different purposes including municipal, agricultural and industrial supplies; stream flow augmentation; flood control; and recreation. No impoundments in Ohio, other than those on the main stem of the Ohio River, provide water for downstream navigation or hydro-electric power generation. However, there is extensive navigation on both Lake Erie and the Ohio River, and consideration is being given to the installation of low-head hydro-electric generators at several developed dam sites throughout the state.

Flooding, still a major problem in Ohio, affects both urban and agricultural areas; and it has been estimated that nearly two million acres of land in Ohio are flood prone. This represents over seven percent of the total area of the state and includes nearly four percent of those areas classified as urban regions. Average annual flood damages in Ohio vary from year-to-year, but amount to several millions of dollars annually.

Ground Water

Ground water is an important part of Ohio's water resources. Ground water underlies most of the state but is predominate in the glacial drift in the northwest, in the ice-contact and outwash deposits in river valleys along the border of the glaciated areas, and in the bedrock of the western portions of the state. Ground water supplies are largest in the glacial valley-train deposits in those drainage basins which border the Ohio River including the Ohio, Miami, Little Miami, Scioto, Hocking and Muskingum Rivers. Well yields from these deposits often exceed 500 gallons per minute (gpm), while aquifers in the glacial drift in the northwest and west-central parts of the state produce yields between 100 and 500 gpm. Isolated aquifers in the northeast, northwest and southwest have yields between 25 and 200 gpm, while much of the northeast contains aquifers whose yield is between 5 and 25 gpm. With the exception of the valleys along the major streams, most of the aquifers in the area that is tributary to the Ohio River have yields less than 5 gpm.

Three-quarters of Ohio's 650 public water supply systems use ground water as their source. In terms of volume withdrawn, however, a lesser share of these supplies comes from ground water, for only around a half billion gallons of ground w ater are withdrawn each day for public water supply purposes, while over one billion gallons come from surface water sources. However, ground water supplies nearly 80 percent of the rural water needs in Ohio, 32 percent of the irrigation waters and 21 percent of the industrial water demands. Nearly one billion gallons of ground water are withdrawn in the state each day to meet these needs.

Water Quality

It is the quality of water, rather than its quantity, that is the more critical and limiting condition associated with the use of both ground and surface waters in Ohio. The ground waters of the state frequently have relatively high, natural mineral contents; but, except for a few local areas, most of these waters are free from man-related contamination. Most complaints are related to increased levels of turbidity, bacterial populations and other substances from improperly sited or poorly constructed or maintained wells. Other problems are related to the spillage and leakage of brines and petroleum at oil wells in the southeastern part of the state; the mis-application of pesticides, herbicides and insecticides in agricultural areas; and the improper siting and operation of solid and liquid waste disposal facilities. Some minor ground water problems associated with the excessive use of highway de-icing salts or its improper storage have also been reported.

The dissolved solids concentrations in Ohio's streams range between 120 and 2,500 milligrams per liter (mg/l). The higher concentrations are found in the Tuscarawas, Cuyahoga and Grand Rivers and in other stream reaches below major municipal and industrial outfalls or in areas subjected to diffuse source runoff.

Of the 23,000 miles of the principal rivers downstream of major urban areas in the state that have been monitored 16,000 miles, or 70 per cent of these streams, meet the current water quality standards. Where problems do exist, they are frequently caused by inadequate municipal wastewater treatment at facilities that need be upgraded or expanded, or by combined sewer overflows. Substantial improvements in surface water quality have resulted from the development of pretreatment regulations for industrial waste discharges to municipal sewerage systems. Violations of the state's water quality standards occur most often in dissolved oxygen levels; ammonia nitrogen concentrations; the numbers of fecal coliforms; and the levels of heavy metals such as lead, zinc, and cadmium.

Acid mine drainage is a major cause of water quality problems throughout the Appalachian Coal Basin in the eastern United States. In Ohio this region extends in a band approximately 50 miles wide in a southwesterly direction from the east-central to the south-central parts of the state. Acid drainage from abandoned and improperly operated or reclaimed coal mined lands causes a loss of water for domestic and industrial uses; the degradation of water quality for recreational purposes; a lethal impact on the aquatic life in a stream; and, an accelerated deterioration of highway and railroad bridges and electrical transmission lines and towers. Drainage from abandoned coal mines, both surface and underground, has impacted around 1,500 miles of streams in 27 counties in southeastern Ohio. Approximately 370,000 acreas of abandoned strip mines, 7,000 acres of coal refuse piles and 3,000 underground mines are contributing to this problem. It has been estimated that four billion dollars would be needed to reclaim the abandoned mines and refuse piles throughout Ohio. Projected revenues from severance taxes earmarked for abandoned mine reclamation come to about ten million dollars annually. Obviously, the technologic problems and the economic costs associated with the control of acid mine drainage will continue to keep this a major problem of water quality in southeastern Ohio for years to come.

Little detailed information is available concerning the impacts that diffuse sources of pollution such as agricultural and urban stormwater drainage have on the quality of water in Ohio's inland streams. One concern with non-point pollution is the sediment that is dislodged from the land surface and carried to the streams. Of greater concern are the pollutants, such as the nutrients, heavy metals and toxic organic substances, that enter the streams attached to the sediments. No need for intensive, non-point source control programs to meet water quality standards in that area of the state that drains to the Ohio River has been shown; but several studies are underway in the Lake Erie drainage basin to define the role of agricultural drainage on the water quality in Lake Erie. Much more research and many more demonstration projects on

the best management practices for agriculture, silviculture, mining and urban runoff control must be conducted before this problem is fully understood and control measures can be instituted.

The trophic status of several lakes and reservoirs has been studied; and results to date suggest that the lakes and reservoirs in the sandstone bedrock areas of the state have generally lower trophic levels than those in the limestone bedrock areas or glaciated regions. Water quality was generally good to excellent in most of the lakes and reservoirs surveyed. However, excessive concentrations of copper and other heavy metals, bacteria and other pollutants normally associated with urban activities were identified in some of the lakes.

Recent studies on Lake Erie indicate that there has been a reduction in several key pollutants and a gradual, but steady, improvement in the water quality in the Lake during the past few years. Phosphorus is a major pollutant which results in the excessive growth of algae and other aquatic plants. As these plants die and decay, they deplete the oxygen resources of the Lake. The construction of faciliites to remove phosphorus at those municipal wastewater treatment plants which discharge directly to Lake Erie has been a major factor in the reduction of phosphorus loadings and of the subsequent reduction of the anoxic areas within the Lake. Additional work on the control of phosphorus from both diffuse sources and point sources needs be accomplished, but a significant start has been made.

Levels of bacteria have been reduced in the nearshore zones where municipal wastewater treatment facilities have been constructed. This has permitted regulatory agencies to re-open bathing beaches which were often closed during the period between 1960 and 1970. Concentrations of mercury and pesticides have been reduced substantially, principally because of the federal bans that have been instituted on their manufacture, use and disposal. PCB remains a major challenge, as does the control of sediment and the nutrients, fertilizers and organic chemicals that are attached to it.

Fish populations, including the walleye pike, are beginning to increase again in the lake; but the quality and diversity of fish is still far from what they were in the past. Thermal pollution is a localized problem in some near-shore areas. However, as closed cycle cooling is required on all power generation facilities, the extent of this problem will diminish.

PROGRAM GOALS AND PRIORITIES

The Water Resources Center at The Ohio State University encourages and supports research that is directed at providing information needed to solve the major water problems at the local, state, regional and national levels. The research program at the Center includes basic or fundamental research, problem oriented or applied research, and information dissemination and technology transfer activities.

During FY 1982, the Center, in cooperation with several groups of water-related agencies and officials throughout the State prepared a prioritized list of Ohio's major water resources problems. Based upon this analysis, the following ranking of these problems was developed:

1. POLLUTION FROM DIFFUSE SOURCES - including agricultural runoff; urban runoff; runoff from on-site waste disposal systems; runoff from active, reclaimed or abandoned coal and strip mines.

2. CONTAMINATION OF DRINKING WATER SUPPLIES including surface and ground waters for both urban and rural uses by diffuse and point sources, and by the disposal of toxic and hazardous wastes on the land.

3. TOXIC AND HAZARDOUS WASTE DISPOSAL - including their control, treatment, disposal and impact upon land, water and air resources.

4. POLLUTION FROM POINT SOURCES - including municipal and industrial sources not yet in compliance with their NPDES permits.

5. IMPACTS OF FLOODING AND DRAINAGE - including flood damages, the use of flood plains and alternative sturctural and non-structural means of controlling floods and reducing flood damages.

6. IMPACTS OF WATER RESOURCES DEVELOPMENTS - including the impacts on various land uses caused by structural and non-structural water resources developments such as the extension of water mains and sewers into rural areas; flood control projects; hydro-electric power generation; water-based recreation; etc.

7. INSTREAM FLOWS NEEDS - including interrelationships among water quality, water quantity and land use practices on the instream flow needs for fish, wildlife, and recreation and the optimum development and protection of these instream uses.

8. IMPACTS OF SYNTHETIC FUEL DEVELOPMENT - including requirements for water and impacts of the disposal of wastes from these processes into waters and onto the land.

9. IMPACTS OF ATMOSPHERIC POLLUTION - including the effects of acid precipitation and atmospheric fallout on water quality and the environment.

10. ALLOCATION OF WATER RESOURCES- including the development of contingency plans for the allocation and conservation of limited water supplies among competing water users during periods of low stream flows.

Subsequently, the Directors of the Water Resources Research Institutes in the Great Lakes, Upper Mississippi and Ohio River Basin's met to identify from their State problems the major water resources research priorities for the Region. A listing of these priorities is included in Attachment 1 in the Appendix to this Report.

The focus of the 1984 State Water Resources Research Program was primarily directed at some of these critical needs. The research and technology transfer program consisted of the following activities:

The project by L. S. Fan entitled "Optimal Design and Operation of a Draft Tube Gas-Liquid-Solid Fluidized Bed Bioreactor for Treatment of Wastewater from Coal Processing - Phase II" continued to explore the behavior of this device and developed operating criteria to enhance the removal of phenol in the wastewaters from various coal processing operations. When completed, this project will aid in the development of a more efficient and less costly method of removing this potentially toxic substance from coal procesisng wastewater, thereby increasing the utility of the region's vast coal resources.

Three of the projects in the program explored the significance of phosphorus on the water quality in the state's and region's surface waters.

Dr. Logan's project, entitled "Modeling the Transport of Dissolved Phosphate from Agricultural Land", provided a technique to estimate the amount of dissolved phosphorus that is being transported in the surface runoff from agricultural lands and will permit better predictions of the impacts that conservation tillage and more effective fertilizer management practices have on the surface water quality in the agricultural drainage basins of the Great Lakes.

The project by Drs. Krieger and Baker entitled "Alteration of Stream Ecosystem Function and Structure by Agricultural Herbicides" better defined the role that atrazine, alachlor, metachlor and metribuzin play in inhibiting photosynthesis and the removal of nutrients, such as phosphorus, in the streams in the Lake Erie basin by altering the concentration and the species of the aquatic biota in those streams.

The project by Drs. Herdendorf and Rathke, entitled "Dynamics of Bioavailable Phosphorus in Lake Erie as Related to Phosphorus Loading", investigated the relationship that exists between the quantities of bioavailable and non-bioavailable particulate phosphorus in Lake Erie.

The results of this project will be used to permit a more realistic estimate to be made of the reductions in the phosphorus loadings from point and non-point sources that must be achieved to continue to improve the water quality within the Lake.

Dr. Johnson's project, entitled "Preference of Fish Larvae for Habitat Types in a Water Level Controlled Lake Erie Wetland", will provide information to the water managers in the state and regional agencies to allow them to better manipulate the fish population in Lake Erie by altering the type of habitat within the region's managed wetlands by controlling the depth of water in those wetlands.

The project by Drs. Bedford, Scott and Rathke, "Measurement and Parameterization of Lake Erie Nearshore Transport and Mixing Processes", explored the quantities of materials involved in the transport of sediment and pollutants from the Lake Erie shore line through the near shore zone to the off shore receiving waters. The effective management of pollutant loadings to the Lake depends on a thorough knowledge of the flux of materials from the shore line to the open waters of the Lake.

The technology transfer program of the Water Resources Center will assist in the development and distribution of a computer program to allow farmers throughout the state to calculate the potential loss of soil from their fields to the surface streams that drain their farms. The program will also allow the farmer to estimate the reductions in soil loss that might be achieved if different tillage and other soil conservation practices were implemented.

Synopsis

Project Number: 02

Start: 9/01/83
End: 9/30/85

Title: Optimal Design and Operation of a Draft Tube Gas-Liquid-Solid Fluidized Bed Bioreactor for Treatment of Wastewater from Coal Processing - Phase II

Investigator: Fan, Liang-Shih, Department of Chemical Engineering, The Ohio State University.

COWRR: 05D Congressional District: Fifteenth

Descriptors: fluidized bed process, biological wastewater treatment, phenols, draft tube, kinetics.

Problem and research objectives:

Phenolic compounds are one of the major pollutants in the waste streams discharged from coal conversion plants. Phenolic compounds are troublesome contaminents, for toxic polychlorinated phenols can result when phenol-containing water is chlorinated. Environmental regulation requires the phenol concentration in surface water to be lower than 1 mg/l.

Fluidized bed bioreactors have been shown to be more cost-effective and efficient than conventional treatment systems such as trickling filters and activated sludge systems. The objective of this project is to optimize the design and operation of a fludized bed bioreactor for treatment of phenols-containing waste liquors from coal processing operations. In the first year of this research effort, a draft tube three-phase fluidized bed bioreactor (DTFB) was developed and has been shown to yield a bench scale phenol biodegradation rate far exceeding that of all other bioreactors ever reported in the literature. The second year was devoted to the investigation of the fundamental characteristics of the steady state DTFB operations so that the optimal design and operation criteria could be derived.

Methodology:

Approximately 10 to 20% (v/v) 350 um activated carbon particles and 5% (v/v) suspended mixed culture of microorganisms were loaded in the DTFB containing synthetic phenolic waste liquor. The DTFB was initially operated in a batch mode for microorganisms to attach to solid particles after which the DTFB was converted to continuous operation. As the DTFB reached pseudo-steady state operation, the inlet liquid flow rate, inlet phenol concentration, outlet phenol concentration, and the characteristics of the biofilm were determined. The relationship between the phenol removal rates and the operation conditions such as phenol

loading rates and the biofilm characteristics could then be evaluated.

Principal findings and significance:

A phenol biodegradation rate as high as 18 kg/cm^3-day for effluent phenol concentration less than 1 ppm was achieved in the DTFB reactor with 12.7% initial solid loading. Denser and thinner biofilms were produced in the DTFB. The dry density of the biofilms cultivated in the DTFB was found to be much higher than that of the biofilms cultivated in the other types of bioreactors at the same biofilm thickness. The diffusivities of phenol and oxygen within the biofilm were found to range from 5 to 13.3% of the diffusivities of phenol and oxygen in pure water system, and were found to decrease with increasing biofilm dry density.

A mathematical model which considers the simultaneous transport of phenol and oxygen, and the biodegradation of phenol within the biofilms in the DTFB under steady state operation was proposed. Such a model can provide the information regarding the relationship between phenol removal rates and phenol loading rates, and between phenol conversion fraction and phenol loading rates, thus provides a useful tool to identify optimal operational conditions for the DTFB bioreactor.

Publications and professional presentations:

(1) Fan, L. S., S. H. Chern, and K. Murayama, 1984. "Solids Mixing in a Gas-Liquid-Solid Fluidized Bed Containing a Binary Mixture of Particles,"AIChE Journal, 30(5):858-860 (1984) L.S. Fan S.H. Chern, and K. Muroyama.

(2) Fan, L. S., A. Matsuura, and S. J. Hwang, 1984."Some Remarks on Hydrodynamic Behavior of a Draft Tube Gas-Liquid- Solid Fluidized Bed." Presented at the AIChE Annual Meeting, Washington, DC, October 30 - November 4, 1983, AIChE Symposium Series No. 234, Vol. 80, 91-97

(3) Fan, L. S., K. Fugie, and T. R. Long, 1984."Some Remarks on Gas-Liquid Mass Transfer and Biological Phenol Degradation in a Draft Tube Gas-Liquid-Solid Fluidized Bed-Biofilm Kinetics,". Presented at the AIChE Annual Meeting, San Francisco, California, November 25-30, 1984, AIChE Symposium Series, 241, Volume 80, 102-109.

(4) Wisecarver, K. D., W. T. Tang, and L. S. Fan, 1985. "Simultaneous Adsorption and Biodegradation of Organic Substrate Using Activated Carbon Particles with Immobilized Living Cells: Experiments, Modeling, and Simulation,".To be presented at the ACS National Meeting, Chicago, Illinois, September 8-14, 1985; K.D. Wisecarver, W.-T. Tang, and L.-S.Fan.

M.S. theses:

(1) Arters, D.C.,1984. "Solid-Liquid Mass Transfer in a Three-Phase Fluidized Bed," M.S. Thesis, The Ohio State University.

(2) Tang, W.T., 1985. "Steady State and Transient Phenol Biodegradation by Mixed Culture in a Draft Tube Three-Phase Fluidized Bed Bioreactor," M.S. Thesis, The Ohio State University.

Ph.D. dissertations:

(1) Hwang, S.J.,1985. "Hydrodynamics and Mass Transfer in a Draft Tube Gas-Liquid-Solid Spouted Bed," Ph.D. Dissertation, The Ohio State University.

Synopsis

Project Number: 03

Start: 9/01/83
End: 9/30/85

Title: Dynamics of Bioavailable Phosphorus in Lake Erie As Related to Phosphorus Loading.

Investigator: Rathke, David E., Research Associate; and Herdendorf, Charles E., Director, Center for Lake Erie Area Research, The Ohio State University.

COWRR : 05B

Congressional District: Fifteenth

Descriptors: phosphorus, nutrients, bioavailable phosphorus, Lake Erie

Problem and research objectives:

The increased eutrophication of Lake Erie has been attributed to excessive external phosphorus loadings. The concentrations of phosphorus measured in the lake during an entire field season result from both external and internal sources. Neither loading sources can be considered to imput phosphorus that is 100% bioavailble. In order to evaluate the lake's response to reduced external loadings, primarily from municipal sewage treatment plants, bioavailable and nonavailable phosphorus must be quantified. This information will provide the necessary corrections to existing predictive models utilized as management tools in the implementation of the phosphorus control program on the Great Lakes.

The goal of this study was to develop a relationship between the quantity of bio-available phosphorus entering the lake through external loading and that entering the phosphorus cycle through internal processes.

This study had four major objectives:

1. To determine the seasonal and spatial distribution of the three particulate phosphorus components; Apatite phosphorus, (AP), Non-apatite inorganic phosphorus (NAIP), and Organic phosphorus (OP).

2. To correlate the seasonal compositional changes of particulate phosphorus to the composition of the total particulate material found in the water column; ie. chlorophyll, volatile solids, fixed residual solids, and particulate organic carbon.

3. To utilize correlations between the fractions of particulate phosphorus and the various components of total particulate matter found in the water column to estimate the composition of the particulate phosphorus for years prior to 1980.
4. To develop a phosphorus budget for the central and western

basins using bio-available phosphorus loading and in-lake concentrations.

Methodology:

Phosphorus measurements have been routinely made throughout Lake Erie since 1970, with total phosphorus measurements being identified as the most important form of phosphorus to measure in order to assess the changes in the trophic condition of the lake. In addition to the conventionally measured total phosphorus, four forms were routinely measured during this study:

1. Total Phosphorus (TP)
2. Total Filtered Phosphorus (TFP)
3. Soluble Reactive Phosphorus (SRP)
4. Soluble Organic Phosphorus (SOP)
5. Total Particulate Phosphorus (PP)

Particulate phosphorus can be further fractionated with two components most commonly quantified:

1. Acid Extractable Fraction
2. Sodium Hydroxide Extractable Fraction

The acid extractable fraction is primarily identified as phosphorus bound with calcium in the form of apatite phosphorus. This fraction is considered to be unavailable for biological incorporation and thus does not enter the phosphorus cycle in the lake (Williams 1976). The sodium hydroxide extractable fraction is considered to be potentially available. This fraction can be partitioned into organic and inorganic portions in which the inorganic form is considered potentially available for short term biological processing while the organic is not considered to recycle as quickly.

A total of 30-50 liters of water was collected at each sampling depth for phosphorus fractionation analysis. Particulate material larger than 0.5mu was concentrated to a volume of 1 liter using a Millipore "Pelicon Cassette System". This concentrate was then freeze dried leaving the concentrated particulate material from the original water sample. This particulate matter underwent a series of fractionations. Methods employed were similar to those developed by Chang and Jackson (1956) for phosphorus fractionation studies of Lake Erie sediments. The methodologies being employed have also been used for such studies on numerous tributaries around the lake (Logan et al. 1979, DePinto 1980).

In addition to samples for phosphorus fractionation analysis, water was collected throughout the water column for chlorophyll, total suspended solids, fixed residual solids, volatile solids, and particulate organic carbon.

Findings and significance:

Since 1970, only small in-lake responses to the reduction in phosphorus loadings have not been evident, even though loadings have been reduced by 40% over the last decade. In order to clearly identify whether or not the loading reduction has as yet led to a reduction in the in-lake concentrations of phosphorus, this detailed approach was necessary. Since the total quantity of phosphorus present in the water is not necessarily related to the quantity of bioavailable phosphorus, attempts to model lake responses based on only total phosphorus values may not be valid. It is necessary to establish a seasonal data base for bio-available phosphorus in order to relate these values to the total concentrations already measured since the late 1960's. Given a relationship between total phosphorus /bio-available phosphorus/and related particulate material suspended in the water column, a more complete understanding of Lake Erie phosphorus dynamics is being developed.

The first objective of this study involved the quantitative and qualitative determination of particulate phosphorus forms by chemical fractionation. Utilizing the particulate phosphorus fractionation procedure outlined in the methods section, concentrations and seasonal distribution patterns for the forms were determined. Of the total particulate phosphorus measured, the available portion varied from 30 to 80% depending upon the nature of the particulates in the water column. During periods of resuspension the percent of available phosphorus decreased due to an increase in the percent apatite phosphorus. In contrast, during the summer months when organic material dominated the particulate fraction, the percent of available phosphorus increased proportional to the organic content.

Results indicate that from 10 to 60% of the total suspended particulate phosphorus in the water column is not in a form considered to be bio-available. This means that from 5 to 30% of the total phosphorus measured may not be bio-available depending on the location within the basin and the time of year the measurements are made. For example, along the northern shore of the central basin, the non-available particulate phosphorus concentrations are expected to be greater than those of other regions of the basin due to bluff erosion of apatite phosphorus containing clays. In addition, the fall has been shown to be a time when non-available phosphorus concentrations are elevated due to bottom resuspension.

The second objective was to characterize the total particulate material found in the water column throughout the season and develop a relationship between the composition of the suspended material and the concentrations of the various phosphorus forms. The composition of the particulate material in the open waters of the central and western basins represents a combination of organic and inorganic material. The proportion of organic/inorganic is dependent upon plankton biomass, resuspension of sedimented material and tributary inputs. The strongest relationship between suspended particulates and available phosphorus was

found with suspended solids. Particulate phosphorus concentrations indicated a linear relationship with total suspended solids (r = 0.8 to 0.9) and an even better relationship with fixed residual solids. Chlorophyll and particulate carbon did not indicate a consistently strong relationship.

Multiple correlations are being used to develop the relationship between chlorophyll, particulate organic carbon, volatile solids, fixed residual solids and particulate phosphorus. This will enhance the relationship between bio-available phosphorus with the overall composition of the suspended material.

The fourth objective was to develop a western and central basin phosphorus budget. This phase is still underway. Previously budgets have only considered total phosphorus (Burns 1976, Chapra 1982) or have utilized the various conventional forms (Svanks and Rathke 1980), but none has been based directly on phosphorus availability. Since the total phosphorus loading estimates are beginning to show significant reductions, particularly since the late 1970's, the anticipated reductions in in-lake concentrations may become apparent. However, as has been previously pointed out, due to the effects of both internal and external loading upon in-lake concentrations, such a trend may not be readily observable. Once the appropriate corrections have been made to the loading data and in-lake concentrations based on availability, a trend analysis of Lake Erie phosphorus concentrations can be prepared.

Publications:

Several papers are being prepared for submission to referred journals. Presentations: "Bioavailability of Phosphorus in Suspended Lake Sediments" presented at Water Sediment Interactions Conference, Geneva, Switzerland August 26-30,1984.

M. S. theses :

None

Ph.D. disserations :

None, but Cheng Mu Shiao, a Ph.D. Candidate in Electrical Engineering is developing a dissertation on a project-related topic. No title has been selected yet.

Literature Cited:

Burns, N. M., and C. Ross, 1972. Project Hypo. Canada Centre for Inland Waters. Technical Report TS-05-71-208-24. 182p.

Burns,N.M., J. D. Williams, J.M. Jaecuet, A. L. Kemp, and D. C. Lam, 1976. A phosphorus budget for Lake Erie, J. Fish. Res. Bd. Can. 33:564-573.

Chang, S.C., and M. L. Jackson, 1975. Fractionation of soil phosphorus, Soil Sci. 84:133-144.

Chapra, S. C., 1982. A budget model accounting for the positional availability of phosphorus in Lakes, Water Res. 16:205-209.

Depinto, J. V., T. C. Young, and S. C. Martin, 1981. Algal-available phosphorus in the suspended sediments from the lower Great Lakes tributaries, J. Great Lakes Res. 7(3):311-325.

Likens G. E. (ed.) 1971 Special Symposia, Vol. 1 Amer. Soc. of Limn. and Oceangr. Inc. Allen Press, Inc., Lawrence, Kansas. p. 328.

Logan, T. J., T. O. Oloya, and S. M. Yaksich, 1979. Phosphate characteristics and bioavailability of suspended sediments from streams draining into Lake Erie., J. Great Lakes Res. 5 (2): 112-123.

Logan, T. J., F. H. Verhoff and J. V. DePinto. 1979. Biological availability of total phosphorus. Lake Erie Wastewater Management Study, U.S. Army Engineer District, Buffalo. 62 p.

Svanks, K., and D. Rathke, 1980. Phosphorus budget for the central and western basins of Lake Erie: 1973-1975. p. 131-174. In: C. E. Herdendorf (ed.). Lake Erie nutrient control program: An assessment of its effectiveness in controlling eutrophication. USEPA Tech. Rept. 600/3-80-062.

Williams, J. D. H., J. M. Jaquet, and R. L. Thomas, 1976. Forms of phosphorus in the surficial sediments of Lake Erie, J. Fish, Res. Board Canada 33 (3):413-429.

Synopsis

Project Number: 04 Start: 9/1/83
End: 9/1/85

Title: Preference of Fish Larvae for Habitat Types in a Water Level Controlled Lake Erie Wetland.

Investigator: Johnson, Dr. David L., The Ohio State University,

COWRR: 06D Congressional District: Fifteenth

Descriptors: fish larvae, habitat structure, wetlands, aquatic vegetation, cover

Problem and research objectives:

In this two-year research effort, we are investigating larval fish preferences for various habitat types in a controlled wetland. It has been shown that habitat structure can mitigate the effects of predation on young fish, thereby influencing their abundance. It is important to know which vegetation types are most important to various fish species when making management decisions about wetlands.

This research will provide valuable information to marsh managers wishing to select for or control specific fish species. Mitigation of wetland losses will also be aided by knowing the value of lost vegetation types to various fish species; and if feasible, will guide in the replacement of that habitat. The information will also be valuable to regulatory and management agencies in their decision-making process regarding elimination, creation, or enhancement of wetland areas.

In addition to the previous years objectives, we have added objectives for this second year of research: These include:

1. To determine late summer preferences of fish larvae of various species for open water, floating, emergent, and submergent habitat types and also determine if larvae preference changes as the larvae grow.

2. To determine if differences exist in day and night preferences of fish larvae of various species for open water, floating, emergent, and submergent habitat types.

3. To determine the effects of physiochemical variables on fish larvae late summer and day/night use of open water, floating, emergent, and submergent habitat types.

4. To continue preparation of preliminary management plans suggesting and comparing alternative management options designed to improve the function of controlled Lake Erie wetlands in providing spawning and nursery areas for important Lake Erie fish species, especially those species dependent on wetlands for reproduction.

Methodology:

Research is being conducted in the 200 acre West Marsh at the Winous Point Shooting Club in Ottawa and Sandusky Counties, Ohio. "Pop nets" are used to sample fish larvae associated with the different habitat types. Each net has a mesh size of 0.5 mm and samples 2.25m^2 of water. Artifical structures based on mean stem densities calculated for each vegetation type were created using plastic plants (submergent), polypropylene rope and styrofoam disks (floating), and epoxy coated cattails (emergent). These materials were colored dark green to better imitate the natural vegetation. Sixteen sampling locations, consisting of four stations in each of the four habitat types, were established. The stations in each habitat were arranged within or adjacent to natural vegetation to simulate as nearly as possible, a larger homogeneous vegetated area. Daytime samples were collected weekly at four hours after sunrise and night samples were collected at four hours after sunset. Collection of physiochemical data was done simultaneously with collection of larvae. Water temperature, dissolved oxygen, secchi disk, percent cloud cover, and light penetration data were collected for each habitat type on each sampling day.

Principal findings and significance

Larvae collected during the 1984 field season have been enumerated, identified, and measured. Larvae representing five genera including Lepomis, Cyprinis, Dorosoma, Pomoxis, and Ictalurus were collected. Lepomis comprised 69% of all larvae collected followed by Cyprinis(16%),Dorosoma (8.4%), Pomoxis (6.0%), and Ictalurus (0.6%). Preliminary tests indicated a non-normal distribution of the dataset. Several variance stabilizing transformations were tried with little success. It now appears that nonparametric tests will be necessary to analyze the data collected in 1984. Kruskal-Wallis tests will be used to compare mean numbers of larvae collected from each habitat type. If differences are detected between habitats, a multi-comparison test will be used to compare all combinations of means and determine larvae preference for the various habitats.

Samples collected during the 1985 field season are currently being sorted. After sorting, larvae will again be identified, measured, and enumerated by genus. Water temperatures and dissolved oxygen did not appear to differ significantly between habitat types in 1985. Differences in light penetration between habitats appears to be an artifact of wind direction, and no seasonal differences between habitat types are apparent. In 1985 as in 1984, physiochemical variables do not appear to be responsible for distribution of larvae within the marsh.

Publications:

None

M. S. thesis:

None

Ph. D. dissertations:

None.

Synopsis

Project Number: 05

Start: 8-01-83
End: 8-31-85

Title: Alteration of Stream Ecosystem Function and Structure by Agricultural Herbicides.

Investigator(s): Krieger, Kenneth A., and Baker, David B., Heidelberg College, Tiffin, Ohio

COWRR: 05C Congressional District: Fifth

Descriptors: triazine herbicides, chloracetamide herbicides, atrazine, alachlor, metolachlor, metribuzin, algae, agricultural runoff, primary productivity

Problem and research objectives:

Field studies in the southwestern part of the Lake Erie basin in Ohio have shown that widely applied herbicides, especially alachlor, atrazine, linuron, metolachlor and metribuzin occur in agricultural streams in predictable patterns each year at concentrations that collectively have been known to exceed 250 ug/L. Concentrations of most of the herbicides are undetectable during most of the year except for atrazine, but several herbicides are persistent above 1 ug/L for several months during the summer. Laboratory bioassays have demonstrated inhibitation of growth in freshwater algae at atrazine concentrations as low as 1 ug/L, and atrazine at 20 ug/L has been shown to cause changes in pond ecosystems. The combined effects of the suite of residual herbicides which occur annually in northern Ohio streams may exert an important effect on ecosystem productivity and biological structure.

The objectives of this project were to measure the inhibitory effects of atrazine alone and in combination with alachlor, metolachlor and metribuzin on (1) the productivity of naturally derived algal communities and (2) the nutrient uptake rates of the communities, and also to measure the effects on algal species composition.

Methodology:

Six replicate artificial streams were colonized for eight days with Aufwuchs seeded from continuously exchanged creek water. Two streams were then exposed continuously for 12 days to atrazine at 24 ug/L, two streams were exposed to atrazine at 134 ug/L, and two streams served as controls. Daily, beginning on the sixth day of colonization, nutrient concentrations were analyzed for each stream, and input rates of nutrient stock solutions and creek water were monitored, allowing computation of nutrient uptake rates. At the end of the 12-day exposure, the entire contents of each stream were collected, and subsamples of the contents were analyzed for ash-free dry weight, chlorophyll a and algal abundance

and species structure. The experiment was conducted once at 10°C and again at 25°C to determine temperature effects.

In a second, similar experiment, three streams served as controls and three streams were treated for two days beginning on the eighth day of colonization with a combination of alachlor (35 ug/L), atrazine (108-118 ug/L), metolachlor (85-95 ug/L) and metribuzin (16-26 ug/L). After two days the herbicide concentrations were halved, and after two more days herbicides were no longer introduced into the streams. Again daily nutrient uptake rates were determined, and biomass and algal community structure were determined. As before, the second experiment was conducted at 10°C and again at 25°C. Herbicide concentrations were verified frequently during the experiments by capillary column gas chromatography.

Principal findings and significance:

Exposure to atrazine at 24 ug/L and 134 ug/L significantly inhibited the accumulation of dry weight, ash-free dry weight and chlorophyll a. AFDW was 4% less at 10°C and 24% less at 25°C in the 24 ug/L streams than in the control streams ,and was 47% less at 10°C and 31% less at 25°C in the 134 ug/L streams. Chlorophyll accumulation in the 24 ug/L streams was not reduced at 10°C but was 30% less at 25°C. At the 134 ug/L exposure, chlorophyll accumulation was 39% less at 10°C and 44% less at 25°C.

Exposure to the pulse of four herbicides also significantly reduced biomass accumulation, except for chlorophyll a at 25°C. AFDW was reduced by 45% at 10°C and 19% at 25°C, while chlorophyll a was reduced by 32% at 10°C and 6% at 25°C.

Algal community abundance and species composition were more strongly influenced by temperature than by exposure to herbicides. Total algal abundance in the control streams was approximately three times greater after 20 days of colonization at 25°C than at 10°C in both experiments. Continuous exposure for 12 days to atrazine at 134 ug/L and the pulsed exposure to the four herbicides both resulted in a total algal abundance about one-half that in the control streams. At the end of both experiments at 25°C, the blue-green algae comprised about two-thirds of the total numbers under all control and treatment regimes except the combined herbicides exposure. At 10°C the diatoms comprised 56%-97% of all individuals under all regimes. Few consistent taxonomic differences were demonstrated between treatment and control streams. One exception was the blue-green alga Schizothrix calcicola, which comprised two-thirds of the individuals in the control streams but only one-fifth in the streams treated with the four herbicides.

The Shannon diversity index and the Pielou equitability index were very similar between control and treated streams except with the four herbicides at 25°C, in which reduced index values in the control streams were linked to the large contribution of Schizothrix.

As with biomass and algal community composition, temperature differences influenced nutrient uptake rates more than exposure to herbicides. At 10°C, the 134 ug/L streams revealed a 35% reduction of nitrate-N uptake, a 31% reduction in silica uptake and a 14% reduction in SRP uptake after nine days of exposure. The same exposure at 25°C reduced nitrate-N uptake by 25%, silica uptake by 58% and SRP uptake by 8%. Exposure to 24 ug/L revealed uptake rates as high or higher than the control streams except that nitrate-N rates were depressed by about 19% at 10°C and 8-10% at 25°C.

Pulsed exposure to the four herbicides resulted in statistically significant reductions in SRP and nitrate-N uptake at 10°C. The reduction in nitrate-N uptake persisted even after herbicide concentrations declined below detectable levels. At 25°C no statistical differences in nutrient uptake in the pulsed streams were demonstrable, although dissolved silica uptake averaged lower beginning soon after the initial exposure.

The above results support those of single-species acute toxicity bioassays conducted by others which have indicated that atrazine inhibits the productivity of freshwater algae at concentrations similar to those employed in this study. These results also confirm work performed with pond compartments and microcosms which demonstrated ecosystem level effects at concentrations of atrazine as low as 20 ug/L.

Only one other study has been conducted on the effects of atrazine on nutrient uptake. That study and the present project have shown that the uptake of nitrate-N is more sensitive to atrazine exposure than the uptake of phosphorus or silica.

The exposure of the artifical streams to the suite of four herbicides was designed to simulate the environmental exposure pattern and concentrations and to measure the overall effect of those herbicides which are the most concentrated in storm runoff. The measured parameters thus demonstrated combined effects which could not be predicated without extensive testing of the individual herbicides as well as their pairwise and multiple interactions. Several other investigators have realized the importance of such interactions in aquatic ecosystems, but this is the first project which has attempted to simulate actual herbicide combinations and patterns during storm events.

Both the United States and Canada continue to invest in programs designed to reduce the loading of bioavailable phosphorus to the Great Lakes. Thus, the question of whether or not the herbicides accompanying phosphorus in spring and summer storm water reduce the phosphorus uptake rates by stream algae is of significance. The present results indicate that uptake is indeed inhibited, but the overall effect of this inhibition in the presence of other characteristics of storm runoff, such as increased turbidity, scouring and sedimentation, needs further study.

Publication and professional presentations:

The results of this project are being prepared for submission to Archives of Environmental Contamination and Toxicology, and an oral presentation will be given at the 1986 annual meeting of The North American Benthological Society or The Ohio Academy of Science.

M.S.theses:

None. An undergraduate independent study was completed in conjunction with this project, entitled "Effect of Agricultural Herbicides on the Stream Ecosystem," by Kathryn L. Jones, May 1985.

Ph.D. dissertations:

None.

Synopsis

Project Number: 06

Start: 8/01/83
End: 9/30/85

Title: Modeling Transport of Dissolved Phosphate from Agricultural Land

Investigator: Logan, Terry J., Professor of Agronomy, The Ohio State University

COWRR: 05D Congressional District: Fifteenth

Descriptors: water quality, non-point source pollution, eutrophication, runoff

Problem and research objectives:

Phosphorus in the runoff from agriculture land is a major component of the non-point source phosphorus load to Lake Erie where phosphorus is considered the element most significant to the growth of algae. Conservation tillage practices have been shown to be effective in reducing the sediment-bound component of phosphorus in runoff, but they have no measurable effect on the dissolved phosphorus component which is the more bioavailable form. Present computer models do an adequate job of predicting sediment-bound phosphorus losses from agricultural land. We previously developed a dynamic dissolved phosphorus runoff model (DPRM) and during this project we will identify the procedures needed for the measurement of the model parameters and will test and calibrate this model.

The model describes dissolved phosphorus in runoff as a function of runoff rate and volume; and, by terms which describe the pool of labile phosphorus immediately available for desorption, the model further describes the rate of phosphorus desorption and the depth of surface soil with which the runoff water can react.

The purpose of this project was to develop the model parameters and to calibrate a dissolved phosphate runoff model (DPRM). The model is intended to be used with existing hydrologic models. The specific objectives were:

1. To determine phosphorus desorption parameters for input into the dynamic dissolved phosphate runoff model (DPRM).

2. To perform a bench-scale calibration of the model.

3. To computer test the calibrated model against field runoff dissolved phosphate data.

Methodology:

We have previously developed a conceptual model for dissolved phosphorus transport in the surface runoff from agriculture land. The model is based on a mixing concept in which:

$$\frac{dP}{dt} = -g(t) * \frac{P(t)}{V(t)} + C(t) \qquad \ldots.(1)$$

where, at any time (t):

g(t) = Outflow rate, liters/sec
P(t) = Total dissolved phosphorus in runoff, Kg
V(t) = Total runoff volume, liters
C(t) = Rate of dissolved phosphorus desorption from surface soil, Kg/sec

Equation (1) is a linear nonhomogeneous first order differential equation, which when solved for P at any time (t) gives:

$$P(t) = \frac{1}{u(t)} P_o + \frac{1}{u(t)} \int_{t_o}^{t} u(t)\, C(t)\, dt \qquad \ldots.(2)$$

where u is an integrating factor and is defined as:

$$u(t) = \exp \int_{t_o}^{t} \frac{g(t)}{V(t)}\, dt \qquad \ldots.(3)$$

where:

Po = The initial amount of dissolved phosphorus in the soil pores or stored at the soil surface that is immediately available for dilution by runoff water

Po and C(t) have been determined for several soils in the Maumee River Basin which have been and are being monitored for surface runoff and for dissolved phosphorus concentrations and loads.

Po can be determined in two ways:

1. By analyzing extracted soil solution (pore water) for dissolved phosphorus after a 48 hour moist incubation.

2. By determining the equilibrium phosphorus concentration, EPCo, from a laboratory batch desorption isotherm.

C(t) can be determined using a sequential batch desorption process we have previously developed with a 5 minute period between desorption cycles.

After the model parameters were developed, they were be tested against field data which were collected in the fall of 1983 using the large rainfall simulator from the National Erosion Laboratory at Purdue University. Adjustments have been made to the model using this data set for calibration. The calibrated model was then tested against field runoff data that we have been collecting since 1981.

During the first year of the study, we developed computer files for the field watershed data and for the data from the rainfall simulator study. We sorted twelve of field monitored events where there was adequate sediment and phosphorus data to establish a chemograph, and we edited 154 events from the rainfall simulator study. We also performed a first run iteration to estimate the coefficients in Equation (2). Samples have been collected and prepared for the laboratory bench-scale experiments.

During the second year of the project, we continued computer analysis of the events from the rainulator and field monitoring studies and determined P characteristics of the surface (0-5cm) depth of the Paulding soils at the rainulator and field sites.

Principal findings and significance:

The factor Po, the initial content of dissolved inorganic phosphorus (DIP) was found to increase within a few years of no-till agriculture as a consequence of release of soluble P from decaying crop residue.

Laboratory leaching of corn stalk residue indicated that considerable soluble P can be released and either washed directly from the residue during runoff or accumulate at the soil surface. The factor C(t), the desorption of dissolved inorganic P from soil was found, based on chemographs from the rainulator and field monitoring studies, to be sufficiently large to buffer DIP concentrations during runoff events. Independent kinetic studies with 32P on synthetic AlOOH showed that part of the desorption was instantaneous and could be described by a partition constant, while part could be described by a first-order decay coefficient.

Publications and professional presentations:

Nair, P.S., T.J. Logan, A.N. Sharpley, L.E. Sommers, M.A. Tabatabai and T.L. Yuan, 1984. Interlaboratory comparison of a standarized phosphorus adsorption procedure. J. Environ. Qual. 13:591-595.

Miller, J.W., T.J. Logan, and J.W. Bingham, 1984. Kinetic and equilibrium evidence of dual adsorption processes for phosphate on an aluminum oxyhydroxide. ASA Annual Meetings. Agron. Abs. pg. 179.

Stein, O.R., W.H. Neibling, T.J. Logan, and W.C. Moldenhauer, 1984. Effects of tillage and residue cover on runoff and soil loss from a low slope high clay soil. ASA Annual Meetings. Agron. Abs. pg. 254.

Logan, T.J., W.H. Neibling, O.R. Stein and W. C. Moldenhauer, 1984. Effects of reside on phosphorous losses from no-till ridges in a rainulator study. ASA Annual Meetings. Agron Abs. pg. 30.

M. S. thesis:

None

Ph. D. dissertation

None, but Jung Jing, a Ph.D. Candidate in Agronomy is currently developing his dissertation on a topic related to this project.

Synopsis

Project No.: 07

Start: 9/01/84
End: 9/30/85

Title: Measurement and Parameterization of Lake Erie Nearshore Transport and Mixing Processes

COWRR: 5B

Congressional District: Fifteenth

Descriptors: Mixing, dispersion, sediment, pollutants, loading estimates, Great Lakes

Problem and research objectives:

Severe storms have been shown to be the major cause of point source/tributary pollution input into Lake Erie, resulting in the transport of considerable quantities of dissolved and particulate phase material to the nearshore zone. All pollution management plans assume that whatever material enters the nearshore zone is eventually available throughout the Lake; the presumption being that all material is transported throughout the shallow nearshore zone to the deeper offshore waters. Recently a multi-project program of research involving investigators from five universities, NOAA's Great Lakes Research Laboratory and the Canadian Centre for Inland Waters has been initiated to measure and parametertize the amount of dissolved and particulate material escaping the nearshore zone, especially in response to extreme storm and drought events. The site selected for this study is the Sandusky River/Nearshore zone in Lake Erie.

Part of this suite of research projects involved the establishment of a field program for making such estimates. The objective of this one year project was to develop the background material needed for the field program by: (1) performing initial numerical modeling; (2) reviewing existing data; and, (3) collecting preliminary field measurements to develop the initial sampling program for the FY 86 studies.

Methodology:

The following methods were employed. (1) A considerable quantity of data exists for the Sandusky Bay/Nearshore Zone. These consist of water quality data, which is stored in the computerized Great Lakes data banks; and meteorological data and water level data which have been collected at the nearby Marblehead gage. These data have been gathered and analyzed to establish the expected or dominant (re. project design) condition. These expected conditions were then used to calculate a series of probable plume paths for the waters leaving the Sandusky Bay and entering the Lake.

(2) A suite of existing two-and three-dimensional hydrodynamic and transport models have been adapted and applied to Sandusky Bay and to the

Sandusky Nearshore Zone. Data collected by Baker and Richards at Heidelburg College were used to make a series of runs using the design condition identified in step one above. The direction of the plume path, the extent of plume and the rate of offshore transport for each expected condition were calculated.

(3) During the summer of 1985, a series of background studies were performed and monitoring data were collected. Performed simultaneously with the Lake-wide USEPA monitoring program which is being conducted by The Ohio State University's Center for Lake Erie Area Research, a series of two V-shaped transects originating at the mouth of the Bay were surveyed approximately at two weeks intervals.

In addition to the water quality variables, a series of computer/satellite-tracked drifter buoys were released at the beginning and retrieved at the end of each cruise to determine the path of Sandusky Bay Waters as they enter the Lake.

Principle findings and significance:

(1) The data show four extreme conditions that need to be surveyed, with the spring flood being the obvious major event.

(2) Storm surges result in significant retardation of the flow of tributary/nearshore water to the offshore zone.

(3) Very little thermal stratification, if any, exists in the nearshore zone.

(4) The plumes hug the South Shore of Lake Erie after exiting the tributary unless a greater than one-in-five year storm event occurs (except for the spring flood discharge).

(5) The sampling program must resolve the effects of seiche activity in the Lake.

(6) A complete sampling program, including sampling schedules and frequencies has been developed. The first deployment of a stationary monitoring tower at the mouth of the tributary will be made during October, 1985.

(7) Initial results from this year's work indicate that not nearly as much material is transported offshore as was previously anticipated.

Publications and professional presentations:

As of this writing, data are only now being more completely analyzed. Publications on this project are scheduled to be completed next spring.

M. S./Ph.D. theses

This work will contribute to two M.S. Theses which are scheduled for completion during the Spring of 1986.

INFORMATION TRANSFER ACTIVITIES

A series of five tasks were continued or initiated to transfer and dissemination information developed by researchers affiliated with the Water Resources Center to a wide range of State, Federal, County and Municipal agencies; to the private sector; to the academic community and to private citizens throughout Ohio.

Ohio Water Resources Directories

The Water Resources Center has completed the development of a directory of water related agencies within the state of Ohio. A directory of the international, federal, state, interstate, regional and local water agencies was published about ten years ago by the Water Management Association of Ohio, but there have been several revisions in the governmental agencies and in personnel since the original directory was published. The assistance and support of the principal water-related state and federal agencies and of the Water Management Association of Ohio will be obtained before the directory will be published during FY 1985.

The Water Resources Center is also planning the development and distribution of a directory of the scientific expertise available in all areas of water resources research at the Universities within the State of Ohio. A questionaire has been prepared and will be distributed shortly to all the researchers and research administrators at the forty-two Universities and colleges that are known to have demonstrated expertise in some field of water resources research. Key personnel at these Universities will be asked to circulate the questionaries on their own campus to develop a wide response, but we are not planning on a program of extensive follow-up calls to attract responses. When the questionaires are returned to the Water Resources Center, the information will be keyed into our computer and the final directory will be prepared. Funds from the cooperating Universities and from the State water related agencies will be sought to help defray the costs of publication and distribution.

Water Luncheon Seminars

The Water Resources Center continued to co-sponsor a bi-monthly Water Luncheon Seminar Program for the water resources community in Central Ohio. This program, which was developed cooperatively with The Ohio Department of Natural Resources (ODNR), the Ohio Environmental Protection Agency (OEPA), the Soil Conservation Service (SCS), the District Office of the United States Geological Survey (USGS), and the Agricultural Engineering Cooperative Extension Service of The Ohio State University, continues to attract around 70 water resources professionals from Federal, State, County and Municipal Agencies, the private sector and the academic community to a forum to discuss current state, federal and local water policy issues, problems, programs and research results. In addition to providing speakers for one meeting a year, the Water

Resources Center maintains the mailing list and produces and distributes the announcements for this program.

Listed below are the speakers and their topics that were presented during this year's meetings.

Water Luncheon Seminar, FY 1984

Date	Speaker	Topic
9/5/84	Bruce Pickens, Administrator Ohio Dept. Natural Resources	Dam Inspection Project
11/84	Glenn O. Schwab, Professor Dept. of Agricultural Engineering The Ohio State University	Water Management in Holland: What Can We Learn From the Dutch?
1/8/85	Kevin J. Breen, Hydrologist U. S. Geoglogical Survey	Brine Pollution in Ohio
3/12/85	Dr. L-S Fan Chemical Engineer The Ohio State University	Fundamentals of the Draft Tube Gas Liquid Solid Fluidized Bio Reactor for Waste Treatment
5/7/85	Dana Chapman, P. E. Project Engineer Auglaize Soil Conservation Service	Watershed Projects

Soil Erosion Computer Program

The Water Resources Center Director, with consultation provided by the Ohio Cooperative Extension Service, has completed the development of an interactive computer software program to assist farmers throughout the state in estimating the rate at which soil is eroded from their agricultural lands. This program which is based on the revised Ohio Technical Guide for Agricultural Soil Erosion, will predict the potential soil loss from agricultural land based on information provided by the land owner.

If an excessive rate of soil erosiion is predicted from information provided by the farmer, the program will suggest several management and cropping alternatives which the farmer might employ to reduce the loss of soil from the land surface; and coincidentally to improve the quality of the state's surface water.

Consultation and Collaboration Activities

The Center has continued to meet with the leading water resources officials in the state for the purposes of consultation and collaboration to identify the major water problems and the research needs of the state and region; to share information on current water management and policy

issues; to seek continued support for our water research program and to disseminate the information and technology developed through this program and others at the universities throughout the State and Region.

The Director served on the Governor's Advisory Committee for the development of a Strategic Plan for Ohio's Natural and Physical Environment and he presented a paper entitled "The Role of the University in Water Resources Management" at the United States Geological Survey Conference on Water Resources Management.

The Director also serves as one of the Universities' representatives to the newly organized Ohio River Basin Consortium for Education and Research and may be elected as a member of the Board of Trustees of that organization during the Consortium's organization meeting in November, 1985.

Program Evaluation

The Center provided limited support for an effort conducted by Dr. Robert L. Vertrees, Assistant Professor of Natural Resources, The Ohio State University, to complete the development of a methodology of evaluating the effectiveness of the water research program of the Center and other departments in the University in meeting the water resources research needs in the State. Dr. Vertrees presented a paper entitled "A Matrix and Accompanying Classification for Identifying Water Research Problems and Needs" at the twentieth annual conference of the American Water Resources Association in Washington, DC.

COOPERATIVE ARRANGEMENTS

Program Development

A program announcement that included the research priorities identified for the major water problems in the Great Lakes, Upper Mississippi and Ohio River Basins by the Water Resources Research Institutes in the region was sent to research administrators and qualified faculty investigators at forty private and public colleges and universities throughout Ohio on November 21, 1983.

This announcement, which is included as Attachment 1 in the Appendix, also contained some preliminary guidelines for the submission of proposals that had been discussed at a meeting of the Council of Representatives of the National Association of Water Institute Directors (NAWID) with the Assistant Chief Hydrologist for Operations in the Geological Survey and his staff in Reston, Virginia on October 28, 1983. The complete distribution list for this mailing, which contained over 250 names, is included as Attachment 2 in the Appendix. As the federal guidelines from the Geological Survey were not available at the time these preliminary guidelines were distributed, interested investigators were instructed to contact the Water Resources Center if they wished to participate in the program and receive a copy of the federal guidelines when they were available.

Federal Guidelines

The federal guidelines were requested by twenty-nine investigators and research administrators at nine colleges and universities in Ohio. A copy of the federal guidelines for the program is included as Attachment 3 in the Appendix and a list of the investigators who requested these guidelines is included as Attachment 4.

Evaluation/Selection Procedures

Seventeen proposals from seven universities and colleges throughout the state were submitted for consideration and funding. These proposals were subjected to a technical review by at least three qualified evaluators selected by individual members of the Water Resources Center's Advisory Committee. Many of these evaluators were from state and federal agencies and from universities other than Ohio State.

In addition, the synopses of the seventeen proposals were sent to the appropriate directors in the three principal state and federal water-related agencies within the State, requesting that the agencies review the proposals and designate a representative to participate in the process of selecting projects for this program. The agencies contacted were the Ohio Department of Natural Resources; the Ohio Environmental Protection Agency, and the United States Geological Survey.

The results of these reviews were presented at a meeting of the Advisory Committee where this panel ranked all of the proposals in the order they felt would best meet the needs and objectives of the Water Resources Center's program. The Advisory Committee then instructed the Center's Director to incorporate as many of the proposals in ranked order as funds available for the program would permit.

The membership of the Water Resources Center's Advisory Committee, which includes representatives from five colleges and eleven departments at The Ohio State University and the three representatives of the principal water-related state and federal agencies, is included as Attachment 5 in the Appendix.

Program Management

At least once each quarter, the Director contacts the Principal Investigator on each research and information transfer project to discuss progress made during the quarter and to discuss the next quarter's plan of activities. At this same meeting budget details are reviewed and discussed, and necessary operating and reporting procedures to the Water Resources Center and to The Ohio State University Research Foundation's business office are described.

All of our investigators are urged to publish the results of their findings in the technical literature of their major disciplines and in other journals that are appropriate to the topic of their research. They are also encouraged and invited to present their findings at the Water Luncheon Seminar that is a part of the technology transfer activities of the Center.

The manuscripts that constitute the project completion reports are first reviewed by the Director of the Water Resources Center. As needed, the Director seeks the advise and council of appropriate state, federal and university scientists for methods of enhancing the value of the technical completion reports to the water-related community in the State and in the Region.

TRAINING ACCOMPLISHMENTS

The following tabulation shows, by fields of study and training levels indicated, the numbers of individuals participating in projects that were financed in part with this grant.

Training Category	Training Level				
		Graduate			
	Under-Graduate	Master's Degree	Ph.D. Degree	Post-Ph.D.	Totals
Engineering					
-Chemical	1	2		1	4
-Civil		2			2
-Electrical			1		1
Biological/ Natural Science					
-Biology	1				1
-Fisheries	3	2			5
-Zoology	1				1
Social/ Institutional Science					
-Resource Planning		1			1
Totals	6	7	1	1	15

APPENDIX

OSU

The Ohio State University

Water Resources Center
1791 Neil Avenue
Columbus, Ohio 43210
Phone 614 422-6108

To: The Water Resources Research Community

From: Robert C. Stiefel, Director
Water Resources Center

Subject: Availability of Support for Water Resources Research through the FY 1984 State Water Research Institute Program of the Water Resources Center

Date: November 21, 1983

The Water Resources Center will be soliciting proposals from qualified investigators at Universities and Colleges in Ohio for the Center's FY 1984 State Water Research Institute Program. This year's program will be administered in cooperation with the Water Resources Division of the U.S. Geological Survey in the U.S. Department of the Interior.

Federal guidelines for the program are now being developed and should be available by the end of January, 1984. This is again a transitional year for this Program; but new authorizing legislation is expected to pass the Congress in the next few weeks which will provide continuity and stability for our research efforts in the future. Initially, I anticipate that federal funds for the FY 1984 program will be available by June, 1984 and that all projects must be completed before September, 1985.

However, if the new legislation is approved, it should be possible to continue these projects for a second or third year. In any event, the first year's efforts must be designed in such a manner as to "stand alone" as a research project; and be of a nature that a meaningful project completion report can be developed. It also appears that non-federal cost sharing of one non-federal dollar for each two federal dollars will be required for FY 1984; but that this requirement will increase to a one-to-one match in FY 1985.

It is also anticipated that the use of federal dollars will be limited to direct costs including personnel salaries, fringe benefits, non-expendable equipment; expendable materials and supplies, travel, publication costs and other normal expenses associated with conducting research. Indirect

costs will not be covered by federal dollars, but can be used for non-federal cost sharing. Title to equipment purchased with federal dollars will reside in the Water Resources Center.

Proposals submitted for this program should be directed at one of the research priorities identified for the major water problems in the Great Lakes-Upper Mississippi-Ohio River Region which are included with this memorandum.

This information is being provided to permit additional time for Ohio's researchers to begin to develop their proposals for this program. Federal guidelines will only be provided those researchers who inform us that they are planning to submit a proposal to the program. Please call the Water Resources Center at 614/422-2334 if you have any questions or if you wish more details.

Regional Research Priorities

Great Lakes - Upper Mississippi - Ohio River Region

A. Groundwater contamination

1. Track pollutants through the vadose zone to the groundwater and determine their rate of dissipation in the aquifer.
2. Assess the impacts of the disposal of municipal and industrial wastes and effluents on groundwater systems.
3. Evaluate sources of recharge of the principal aquifers in the region.
4. Determine the effects of the storage of waste heat in aquifers on groundwater quality.

B. Pollution of lakes and streams from non-point sources

1. Assess relative effectiveness of non-point pollution control "best management practices" to meet the demands of P.L. 92-500.
2. Evaluate the effects of atmospheric fallout and precipitation (acids, toxic metals and hazardous trace organics) on public health and the aquatic environment.
3. Estimate the effects of drainage from land use activities in urban areas on surface water quality.
4. Model sediment transport processes and devise techniques for determining sediment delivery ratios.
5. Determine the relative effectiveness of voluntary programs enhanced by various incentives and regulation as mechanisms of implementing non-point pollution control.
6. Predict the impacts that new agricultural technologies will have on surface and groundwater resources.

C. Adverse water resources impacts of energy production and mining.

1. Evaluate the impacts that drainage from mining activities will have on the incursion of acids, toxic metals, radio nuclides and hazardous organic compounds into the environment.
2. Assess atmospheric and aquatic pollution from coal-fired electric generation plants.
3. Assess legal, economic, environmental and social impacts and develop means for resolving water user conflicts associated with siting, constructing and operating energy conversion facilities and mining operations.
4. Examine the potential benefits, public and environmental, from the reclamation of heated waters from power generation.

D. Potential insufficiency of waters for agriculture and rural communities

1. Determine optimal water requirements for crop production and develop practical methods for irrigation scheduling.
2. Evaluate criteria for establishing minimum requirements for the drainage of imperfectly drained soils of the region.
3. Develop water conservation practices and methods for holding and temporarily storing surface and drainage waters for reuse in periods of seasonal suboptimal precipitation.

E. Loss and degradation of water based fish and wildlife habitat.

1. Define the functional and economic value of wetlands including ecological and hydrological mechanisms that influence their integrity.
2. Develop acceptable mechanisms, including incentives and legislation, for preserving publicly and privately owned wetlands.

3. Determine the quality and quantity of instream flow necessary to maintain an active and viable aquatic biota.

4. Determine the potential and incentives needed to increase wildlife and waterfowl production on private lands.

F. Miscellaneous

Develop the relationship between commercial/commodity and recreational use of the major lake and river systems of the region. Research emphasis should be placed on development of sufficient water-based recreational facilities in urban settings.

Distribution List For FY 1984 Program Announcement

1. ANTIOCH COLLEGE, YELLOW SPRINGS, OHIO

   Mr. Robert Bieri, Department of Biology

2. UNIVERSITY OF AKRON, AKRON, OHIO

   Noel L. Leathers, V. Pres. & Provost
   Robert G. Corbett, Coordinator of Research
   Roger F. Keller, Professor of Biology
   Dr. John H. Olive, Department of Biology
   George P. Manos, Department of Civil Engineering
   Michael Cheung, Department of Chemical Engineering
   James K. Hardy, Department of Chemistry
   David H. O'Keeffe, Department of Chemistry

3. ASHLAND COLLEGE, ASHLAND, OHIO

   John D. Baker, V. Pres. for Acad. Affairs
   Dr. Randall Rhoades, Department of Biology

4. BALDWIN-WALLACE COLLEGE, BEREA, OHIO

   Neal Malicky, V. P. Acad. Affairs
   Dr. T. C. Surrarrer, Department of Biology
   Glenn W. Peterson, Chairman, Department of Biology

5. BOWLING GREEN STATE UNIVERSITY, BOWLING GREEN, OHIO

   Kenneth W. Rothe, Provost
   Bayliss L. Prater, Department of Biology
   Dr. R. D. Hoare, Department of Geology
   Dr. Lester J. Walters, Department of Geology
   Dr. William B. Jackson, Director, Environmental Studies Center
   Dr. M. P. Henning, III, Firelands Campus
   Vakula S. Srivivasan, Department of Chemistry

6. CAPITAL UNIVERSITY, COLUMBUS, OHIO

   Walter B. Wiser, Provost
   Dr. Paul M. Zimpfer, Department of Biology

7. CASE WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO

James G. Taaffe, V. Pres., Undergrad. & Grad. Studies
Mr. James T. Koppenhaver, Research Administration
Erwin Dieckman, Research Administration
Joseph F. Koonce, Department of Biology
Dr. N. A. Alldridge, Department of Biology
Dr. Yacov Y. Haimes, School of Engineering
Richard Prober, Div. of Chemical Engineering
Frank B. Cliffe, Jr., Political Science
Benjamin F. Hobbs, Department of System Engineering
Gerald Matisoff, Department of Geological Sciences
Peter McCall, Department of Geological Sciences

8. CENTRAL STATE UNIVERSITY, WILBERFORCE, OHIO

Dr. Lionel H. Newsom, President
Mr. Bernard H. Johnson, Chairman, University Research Committee
Arthur Thomas, V. Pres., Academic Affairs

9. WILBERFORCE UNIVERSITY

Yvonne W. Taylor, V. Pres./Acad. Dean

10. UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

Carl Osterbrock, Vice Provost for Acad. Affairs
Dr. G. Rieveschl, Jr., Vice Pres. for Research
Dr. Jack Gottschang, Dept. of Biological Sciences
Dr. J. Robie Vestal, Dept. of Biological Sciences
Professor Bruce L. Umminger, Dept. of Biological Sciences
Dr. Michael Miller, Dept. of Biological Science
Dr. Louis M. Laushey, Civil Engineering
Dr. J. David Eye, Environmental Health Engineering
Thomas C. Kane, Department of Biological Sciences

11. CLEVELAND STATE UNIVERSITY, CLEVELAND, OHIO

Robert F. Boord, Director of Research Services
Dr. F. M. Galloway, Dept. of Chem. Engineering
Dr. V. K. Mathur, Department of Economics
Dr. Paul Olynyk, Div. of Environmental Science

12. UNIVERSITY OF DAYTON, DAYTON, OHIO

Joseph Stander, V. Pres. Academic Affairs
Joseph Militello, Research Institute
Dr. Albert J. Burky, Department of Biology
Dr. J. D. Laufersweiler, Department of Biology
Charles J. Ritter, Geology Department
Dr. John Rowe, Department of Microbiology
Roy M. Ventullo, Department of Microbiology
University of Dayton, Reasearch Institute

13. DEFIANCE COLLEGE

Mr. Richard Whon, Director of Development
Dean of College
Dr. G. C. DeRoth, Department of Biology

14. DENNISON UNIVERSITY

Louis F. Brakeman, Provost
Dr. Allen L. Robuck, Department of Biology
Dr. Thomas Evans, Department of Chemistry

15. FINDLAY COLLEGE

Dr. Louis F. Chenette, Assistant to the President
W. J. McBride, V. P., Academic Affairs

16. HEIDELBERG COLLEGE

Arthur R. Porter, Jr., V.P. for Academic Affairs
Dr. Howard H. Hintz, Department of Biology
Dr. David Baker, Department of Biology

17. HIRAM COLLEGE

Robert MacDowell, V.P. & Dean of College

18. JOHN CARROLL UNIVERSITY

Arthur J. Noetzel, Academic Vice President
Dr. Edwin J. Skoch, Chairman of Aquatic Ecology
Department of Biology

19. KENT STATE UNIVERSITY

Michael Schwartz, V. Pres., Graduate Studies & Research
Quinten A. Buechner, Admin. Asst. for Research
Dr. James W. McGrath, Dean of the Grad. School
Dr. Waldo Semon, Dept. of Chemistry
Dr. B. Miller, Department of Geology
Dr. Eugene Wenninger, Center for Urban Regionalism and Environmental Systems
Yoram Eckstein, Department of Geology
Marvella Pierce, Research and Sponsored Programs

20. KENYON COLLEGE

Bruce Haywood, Provost
Dr. Robert C. Burns, Department of Biology

21. KETTERING COLLEGE OF MEDICAL ARTS

Winton H. Beaven, Ph.D., Dean and V. Pres., Education

22. MALONE COLLEGE

Richard V. Chambers, V. Pres. Acad. Affairs

23. MARIETTA COLLEGE

William H. Thompson, V. Pres., Dev.
John W. Perry, Biology Department
Dr. David F. Young, Department of Biology
Dr. Paul J. Seyler, Department of Biology

24. MARY MANCE COLLEGE

Sister Kathleen Murphy

25. MEDICAL COLLEGE OF OHIO AT TOLEDO

Dr. J. C. Burnham, Department of Microbiology

26. MIAMI UNIVERSITY

David G. Brown, Exec. V. Pres. Acad. Affairs
Mr. Lloyd Goggin, Vice President, Finance & Business Affairs
Dr. Charles Vaughn, Acting Director of Research
Dr. Christopher Barthel, Jr., Special Asst. for Research Institute for Environmental Science
Dr. Gary W. Barrett, Department of Zoology
Thomas E. Wissing, Department of Zoology
Dr. Robert Winner, Department of Zoology
Dr. Marion W. Boesel, Department of Zoology
Institute of Environmental Science
Office of the Dean, The Graduate School and Research

27. MUSKINGUM COLLEGE

Daniel E. Van Tassel, V. Pres., Acad. Affairs
Professor William Adams, Biology Department
Ray Rataiczak, Coordinator, Science Division
Jack Kovack, Chairman, Department of Geology

28. OBERLIN COLLEGE

James L. Powell, V. Pres. & Provost
Dr. David A. Egloff, Department of Biology

29. OHIO NORTHERN UNIVERSITY

I. Leonard Stright, Acad. Vice President
Dr. Charles C. Laing, Department of Biology

30. OHIO UNIVERSITY

Dr. W. A. Wistendahl, Department of Botany
Neil Buckley, Provost
John R. R. Collier, Associate Dean
Dr. Norman S. Cohn, Director of Research
Adam Marsh, Manager, Research Institute
Moid Uddin Ahmad, Department of Geology
Dr. S. Maier, Department of Zoology & Microbiology
Tiao J. Chang, Department of Civil Engineering
William D. Hummon, Department of Zoology
Donald E. Scheck, Department of Industrial & Civil Engineering

31. OHIO WESLEYAN UNIVERSITY

Lauren R. Wilson, Acting Provost
Dr. William F. Hahnert, Department of Zoology

32. OTTERBEIN COLLEGE

Donald Bulthaup, Act. V. Pres. Acad. Affairs
Dr. Jeanne Willis, Department of Biology

33. RIO GRANDE COLLEGE

Clyde Evans, Provost

34. UNIVERSITY OF TOLEDO

William H. Leckie, V. Pres. Acad. Affairs
Dr. Gary F. Bennett, Biochemical Engineering
Dr. Elliott J. Tramer, Department of Biology
Dr. Peter C. Fraleigh, Department of Biology
Dr. Lon C. Ruedisili, Department of Geology
Lloyd Charlesworth, Department of Geology
Dr. John Gillespie, Director, Urban Studies Center

35. URBANA COLLEGE

Joseph LaLumia, Dean of the College
Dr. C. MacFrederick, Head, Math & Science Department

36. WILMINGTON COLLEGE

Arthur L. Buell, Academic Dean
Dr. Thomas K. Wood, Department of Biology

37. WITTENBERG UNIVERSITY

William M. Wiebenga, Provost
Dr. Nathan J. Bolls, Department of Biology
Dr. Louis J. Laux, Department of Biology
Albert Frasca, Professor of Physics

38. COLLEGE OF WOOSTER

Willins M. Baird, V. Pres. Acad. Affairs
Dr. Elizabeth Coyle, Department of Biology

39. WRIGHT STATE UNIVERSITY

Andrew P. Spiegel, Exec. V. Pres., Prov. & Treas.
Dr. Timothy S. Wood, Dept. of Biological Sciences
Dr. Michael J. Smith, Asst. Prof. Dept. of Chem.
Dr. Ronald G. Schmidt, Department of Geology
B. H. Richard, Geology Department
Paul Pufkhar, Assistant Professor of Geology
Adel Bakr, Department of Geology

40. XAVIER UNIVERSITY

Rev. Francis C. Brennan, S.J., Vice Pres., Acad. Affairs
Dr. Daniel J. Higgins, Department of Biology
Father C. Thepe, Chemistry Department

41. YOUNGSTOWN STATE UNIVERSITY

N. Paraska, Dean, Technical and Community College
Dr. George W. Kelley, Jr., Department of Biology
Dr. L. A. Schroeder, Department of Biology
Dr. Irfan Khan, Asst. Prof. of Civil Engineering
Ikram U. Khawaja, Department of Geology

42. OHIO STATE UNIVERSITY

College of Administrative Science

School of Public Administration
Paul G. Craig
Wilpen L. Gorr
Sven B. Lundstet

College of Agriculture and Home Economics
Max Lennon, V. P., Agriculture Adm.
Kenneth W. Reisch, Assoc. Dean

Agricultural Economics
Norman Rask

Agricultural Education
J. Robert Warmbrod

Agricultural Engineering
Warren L. Roller, Chairman
Gordon L. Nelson
Richard K. White
Glenn O. Schwab
Byron Nolte
Byron L. Bondurant
Conly L. Hansen
Melville L. Palmer

Department of Agronomy
Berlie L. Schmidt, Chairman
George S. Taylor
Neil E. Smeck
Terry J. Logan
Kaye R. Everett
Jerry M. Bigham

Department of Horticulture
Harold A. Rollins, Chairman
Dale W. Kretchman
Daniel K. Struve

School of Natural Resources
Charles F. Cole, Chairman
Robert V. Douglass, Chairman
Albert R. Vogt, Chairman
Robert E. Roth, Chairman
Gordon Gatherum
Kenneth A. Wenner
Robert L. Vertrees
James R. Triplett
Thomas W. Townshend
Thomas M. Stockdale
John F. Disinger
James M. Dowdy
David L. Johnson

OARDC (Ohio Agricultural Research and Development Center)
Jerry J. Halterman, Director

Agricultural Engineering
Robert D. Fox
Philip O. Larsen
Ross D. Brazee

Department of Agronomy
D. M. Van Doren, Jr.

Department of Entomology
Harvey R. Krueger
Benjamin R. Stimmer

Plant Pathology
T. Craig Weidensaul

Department of Forestry
John P. Vimmerstedt

College of the Arts and Sciences

Department of Atmospheric Sciences
Thomas A. Seliga - Director

College of Biological Sciences
William J. Collins, Assoc. Dean
Charles E. Herdendorf - Director, CLEAR
Charles C. King - Ohio Biological Survey
F. Joseph Margraf - Ohio Cooperative Fisheries Unit
Theodore A. Bookout - Ohio Cooperative Wildlife Unit

Department of Botany
Emanuel D. Rudolph, Chairman
Carroll A. Swanson
Ronald L. Stuckey
John A. Schmitt
Gareth E. Gilbert

Department of Entomology
Acie Waldron
D. Lyle Gorman
Susan W. Fisher

Department of Microbiology
William R. Sharp
Robert M. Pfister
James I. Frea
Patrick R. Dugan
William R. Strohl
Olli H. Touvinen

Department of Zoology
John L. Crites, Chairman
Tony J. Peterle
Willard C. Myser
Lewis Greenwald
David Culver
Ted M. Cavender
Walter E. Carey
David H. Stansberry
Carol B. Stein
Roy A. Stein

College of Law
Earl R. Murphy

College of Mathematical and Physical Sciences
Dean Colin Bull

Department of Astronomy
Walter E. Mitchell, Jr.

Department of Chemistry
John S. Swenton
Leo A. Paquette
Devon W. Meek
C. Weldon Mathews
Theodore Kuwana

Department of Geology and Mineralogy
Peter Webb, Chairman
Sidney E. White
Garry D. McKenzie
Gunter Faure

Department of Mathematics
Alan C. Wood, Chairman

Department of Physics
John H. Shaw
N. Narahari Rao

College of Social and Behavioral Sciences

Department of Economics
Richard A. Tybout

Department of Geography
Edward J. Taaffe
John N. Rayner

Department of Sociology
Enrico L. Quarantelli
Saad Z. Nagi

College of Engineering

Donald L. Glower, Dean

Department of Aeronautical and Astronautical Engineering
Stuart L. Petrie
John D. Lee
Michael R. Foster
Rudolf Edse
Odus R. Burggraf

Department of Ceramic Engineering
Dennis W. Readey, Chairman

Department of Chemical Engineering
Jacques L. Zakin, Chairman
Edwin E. Smith
Christie J. Geankoplis
Robert S. Brodkey
Liang-Shih Fan
Edwin R. Haering
Harry C. Hersey
Kent S. Knaebel
Duane R. Skidmore

Department of City and Regional Planning
Oscar Fisch, Chairman
Steven I. Gordon
Kenneth T. Pearlman

Department of Civil Engineering
Robert L. Sierakowski, Chairman
Keith Bedford
Elbert E. Whitlatch
Robert M. Sykes
Alan J. Rubin
Vincent T. Ricca
Charles A. Moore
Scot E. Smith
Tien H. Wu

Department of Electrical Engineering
Hsien C. Ko

Department of Industrial and Systems Engineering
Albert B. Bishop
Thomas H. Rockwell
Gordon Clark

Department of Mechanical Engineering
Charles D. Jones, Chairman
Henry R. Velkoff
Charles F. Sepsy
Lit S. Han
Walter E. Carey

Department of Metallurgical Engineering
George R. St. Pierre, Chairman
Brian Wilde, Director, Fontana Corrosion Center

School of Architecture
John R. Voss, Director, Architecture Adm.

Landscape Architecture
Jot C. Carpenter

College of Medicine
David S. Yohn - Cancer Research Center

Department of Preventive Medicine
John R. Wilkins

Research Foundation
Thomas J. Sweeney, Assoc. V. P., Research
McIver Woody

GUIDELINES

FOR THE PREPARATION AND SUBMITTAL OF PROJECT PROPOSALS TO THE OHIO COOPERATIVE STATE WATER RESOURCES RESEARCH PROGRAM FOR 1984
(A Review of the Federal Guidelines)

SECTION I

A. Purpose. The purpose of this memorandum is to establish procedures for the preparation of proposals to the Ohio Water Resources Center (WRC). The source of funds will be the U.S. Geological Survey (USGS), and the U.S. Department of the Interior.

B. Research Project Proposals. A full narrative proposal and a synopsis prepared by the principal investigator(s) for each proposed project is required. The synopsis must incorporate information to show the relevance of the proposed study to water resources issues or management problems common among States in the region and the contribution the project or activity is expected to make toward their solution.

The synopsis will be entered in the USGS Management Information System and used for program characterization on regional and nationwide scales. The full proposal is to be used principally at the Center for evaluation of the project's technical merit and relevance. Copies of the synopsis and the proposal will be included in the Center's proposal to USGS, however.

C. The synopsis, not to exceed one page, is to consist of:

1. I.D. Number (2 digits) - to be assigned by WRC

2. Title (100 characters or less - adequate to describe theme of research)

3. COWWR Category (one; best fit - from WRSIC abstracting guide).*

4. Keywords (from Water Resources Thesaurus, 3rd edition, OWRT IT 80/1, 1980)*

5. Duration (mo/yr start to mo/yr finish) Note: projects may start on or after June 1, 1984 and must

*If not available, visit or call WRC for information.

end before August 31, 1985. No-cost extensions will not be allowed. Longer duration projects will be considered, provided they contain a reportable element to be included in the FY 1984 program report that must be submitted to the USGS in September 1985. However, no guarantee of additional federal funds for the following year can be made.

6. Federal and Non-Federal funding for FY 1984. The WRC will limit federal funds for each project to $25,000 and non-federal funds of at least 50% of the federal funds must be committed.

7. Name(s), address(es) and telephone number(s) of principal investigator(s).

8. Congressional District of host institution - OSU is in the 15th district.

9. Explanation of need (who wants it?, why?), two paragraphs maximum.

10. Explanation of benefits expected or information to be derived and how it will be used, two paragraphs maximum.

D. The full proposal is to consist of:

1. Cover page - repeat 1-8 from the synopsis. The page should contain signatures of Principal Investigator(s), Department Head, and College Dean.

2. Statement of the critical Regional or State water problems(s) to be addressed by the project.

3. Objectives - Indicate results expected to be achieved by use of grant in performance period and by end of project if of longer duration. Incorporate objectives from FY 1983 grant if project is continuing.

4. Related Research - Show by literature and communication citations the similarities and dissimilarities of this proposed project to completed or ongoing research on the same topic.

5. Methods, Procedures, and Facilities - Provide sufficient information to permit evaluation of the technical adequacy of approach to satisfy objectives. Indicate the stopping point for use of this grant, if project is of longer duration.

6. Progress Review - if appropriate - Review tasks funded in FY 1983, if this project is a continuation request and progress accomplished at time this proposal is prepared.

7. Expenditure Justifications - Explain separately the need for any travel, or major non-expendable property, supplies and miscellaneous expenses. Copies of a budget sheet were attached to the previous announcement for this program.

8. Investigator(s) Qualifications - Include sufficient information on academic achievements and experience of faculty to demonstrate their qualifications to undertake it. Note: this section is not to exceed 3 pages nor list more than 15 of the pertinent publications.

9. Training Potential - Specify the number of students, fields of specialty, and degrees expected to result from participation on the project.

E. Number of copies

Submit the original and nine copies of your proposal. The original and two of the nine copies should not be bound.

F. Submission date

Proposals must be received at the Water Resources Center on or before March 1, 1984 in order to be considered.

G. Other requirements

For those proposals included in the FY 1984 program - 35 copies of a technically reviewed and edited completion report must be received at the Water Resources Center prior to August 31, 1985. There can be no exceptions and researchers who fail to comply will not be eligible for future funds from this program. Please include a reasonable amount of time and the necessary funds to accomplish this reporting requirement in your budget and in your work plan.

Indirect costs may not be charged to the federal share of the project budget, but these costs can be included in the non-federal portion of the budget.

ATTACHMENT 4

REQUESTS FOR FEDERAL GUIDELINES 1984

1. Dr. Ben R. Stinner
   Department of Entomology
   Ohio Agricultural Research
   and Development Center
   Wooster, OH 44691

2. Dr. Roger E. Thibault
   Assistant Professor of
   Biological Sciences
   Bowling Green State University
   Bowling Green, OH 43403

3. Dr. Yoram Eckstein
   Professor of Geology
   Kent State University
   Kent, OH 44242

4. Dr. Robert Heath
   Department of Biological Sciences
   Kent State University
   Kent, OH 44242

5. Dr. V. S. Srinivasan
   Department of Chemistry
   Bowling Green State University
   Bowling Green, OH 43403

6. Dr. Kenneth Krieger
   Heidelberg College
   Water Quality Laboratory
   Tiffin, OH 44883

7. Mr. Robert Mason
   Hamilton County Park District
   10245 Winton Road
   Cincinnati, OH 45231

8. Kent State University
   Attn: Marcie Pendelton
   Division of Research and
   Sponsored Programs
   Kent, OH 44242

9. Dr. Robert L. Vertrees
   Ohio State University
   School Of Natural Resources
   469B Kottman Hall
   2021 Coffey Road
   Columbus, OH 43210

10. Mr. Adam Marsh
    Ohio University
    Office of Research and
    Sponsored Programs
    Athens, OH 45701

11. Dr. Harvey R. Kruger
    Department of Entomology
    Ohio Agricultural Research
    and Development Center
    Wooster, OH 44691

12. Dr. Gerald Matisoff
    Department of Geological Sciences
    Case Western Reserve University
    Cleveland, OH 44106

13. Dr. Irfan Khan
    Department of Civil Engineering
    Youngstown State University
    Youngstown, OH 44555

14. Dr. Robert Corbett
    Department of Geology
    University of Akron
    Akron, OH 44325

15. Dr. Jack Kovach
    Department of Geology
    Muskingum College
    New Concord, OH 43762

16. Dr. Tiao J. Chang
    Department of Civil Engineering
    Ohio University
    Athens, OH 45701

17. Dr. Donald E. Scheck
    Department of Industrial
    and Systems Engineering
    Ohio University
    Athens, OH 45701

18. Dr. Jerry M. Bigham
    Ohio State University
    Department of Agronomy
    420A Kottman Hall
    2021 Coffey Road
    Columbus, OH 43210

19. Dr. Terry J. Logan
Ohio State University
Department Of Agronomy
412C Kottman Hall
2021 Coffey Road
Columbus, OH 43210

20. Dr. James Frea
Ohio State University
Department Of Microbiology
468 Bioscience Building
484 West 12th Avenue
Columbus, OH 43210

21. Dr. David L. Johnson
Ohio State University
Division of Fisheries
367D Kottman Hall
2021 Coffey Road
Columbus, OH 43210

22. Dr. Liang-Shih Fan
Ohio State University
Department of Chemical Engineering
421B Koffolt Laboratory
140 West 19th Avenue
Columbus, OH 43210

23. Dr. Keith Bedford
Ohio State University
Department of Civil Engineering
470 Hitchcock Hall
2070 Neil Avenue
Columbus, OH 43210

24. Dr. William Strohl
Ohio State University
Department of Microbiology
677 Bioscience Building
484 West 12th Avenue
Columbus, OH 43210

25. Dr. Ted M. Zobeck
Ohio State University
Department Of Agronomy
414B Kottman Hall
2021 Coffey Road
Columbus, OH 43210

26. Dr. Robert M. Pfister
Ohio State University
Department of Microbiology
372 Bioscience Building
484 West 12th Avenue
Columbus, OH 43210

27. Dr. Susan Fisher
Ohio State University
Department of Entomology
103 Botany and Zoology
1735 Neil Avenue
Columbus, OH 43210

28. Dr. William J. Collins
Ohio State University
Department of Entomology
152 Bioscience Building
484 West 12th Avenue
Columbus, OH 43210

29. Dr. Charles E. Herdendorf
Director, Center for Lake
Erie Area Research
112 Bioscience Building
484 West 12th Avenue
Columbus, OH 43210

ATTACHMENT 5

WATER RESOURCES CENTER ADVISORY COMMITTEE

COLLEGE OF ENGINEERING

1. Dr. Vincent T. Ricca
   Civil Engineering

2. Professor Edwin E. Smith
   Chemical Engineering

3. Dr. Robert C. Stiefel
   Director
   Water Resources Center

4. Dr. Brian Wilde
   Metallurgical Engineering

School of Architecture

5. Dr. Steven I. Gordon
   City and Regional Planning

COLLEGE OF BIOLOGICAL SCIENCES

6. Dr. Robert M. Pfister
   Microbiology

7. Dr. Jeffrey Reutter
   Lake Erie Programs

8. Dr. William DeMott
   Zoology

9. Dr. David Culver
   Zoology

10. Dr. F. Joseph Margraf
    Ohio Cooperative
    Fisheries Unit

COLLEGE OF MATHEMATICAL AND PHYSICAL SCIENCES

11. Dr. Garry McKenzie
    Geology and Mineralogy

COLLEGE OF AGRICULTURE

12. Dr. Terry J. Logan
    Agronomy

13. Dr. Melville Palmer
    Agricultural Engineering

School of Natural Resources

14. Dr. Robert L. Vertrees
    Resources Management

COLLEGE OF MEDICINE

15. Dr. John R. Wilkens, III
    Preventive Medicine

ADMINISTRATIVE MEMBER

16. Mr. McIver C. Woody
    Ohio State University
    Research Foundation

OHIO ENVIRONMENTAL PROTECTION AGENCY

17. Dr. John F. Estenik

OHIO DEPARTMENT OF NATURAL RESOURCES

18. Dr. William Mattox

UNITED STATES GEOLOGICAL SURVEY

19. Mr. Steven Hindall
    District Chief